EDAQ530 measurement software

Szeged, 2010

Preparing the PC

- All USB port devices require drivers
- www.ftdichip.com (Drivers, setup executable)

Installation steps

- DO NOT connect the device.
- Run the installation program.
  (It does not need any feedback ☺).
- Connect the device.
- Wait for the ‘hardware is ready to use’ message

Installing the measurement software

- Install the .NET framework (2.0 or newer)
- For older versions of the software, install the Microsoft Chart component (no longer needed since version 0.4)
- Create a folder
- Copy all files

Software guidelines

- Follow the installation steps precisely
- Do not mix the program with other software or data
- Keep a backup copy of important files
- Preferably do not start the program from external devices

Running the software

- Connect the hardware to the PC
- After a few seconds, we can start measuring
- Menu system, side panel (popup menus)
- Stop the measurement before quitting the program

What kinds of measurements are supported?

- Even sampling of three signals
- Measurement data is shown online, in amplitude-time graphs
- Numeric display for measurement data is also available
- Signals can be scaled (linear, thermistor)
- Level crossings can be detected, so time intervals and speeds can be measured

Setting the measurement parameters

- We can set:
  - which channels are to be measured
  - the sampling rate
  - the number of data points to be displayed
  - the sensor scaling
  - the level-crossing parameters
  - the number of averages
  - the refresh rate of display

Saving the measurement setup

- Automatic save upon quitting the program
- We can also save it to a specified file
- Useful, because:
  - Loading a single file makes the whole measurement easily repeatable
  - Measurements can be shared, up- and downloaded on the internet
  - Sensor data can easily be transferred to other channels

Scaling and calibration

Signal scaling

- We measure voltage directly, but should like to see the signal monitored by the sensor (eg, pressure)
- Linear scaling, ***x*** denotes the measured voltage
- Thermistor scaling, ***R*** denotes the measured resistance

$$A \cdot x + B$$

$$T = \frac{1}{\frac{1}{298.16\ \mathrm{K}} + \frac{1}{B}\ln\left(\frac{R}{R_{25}}\right)}$$

An example of scaling: linear scaling

- Accelerometers are linear
- For $-g$, we get a voltage V_1
- For g, we get V_2
- The acceleration a is thus:

$$a = 2 \cdot g \frac{V - V_1}{V_2 - V_1} - g$$

An example of scaling: thermistor scaling

- Characteristic data of a thermistor: $B_{25/85}$, R_{25}
- We can enter them directly
- Calibration:
  - At least two known temperatures
  - We have take the acclimatisation time into account

Numeric display

Digital display

- Selected signals are displayed as numbers
- Large figures, easy to see
- Useful if we do not need a graph but want to show the measured value

Continuous registration
(chart recorder)

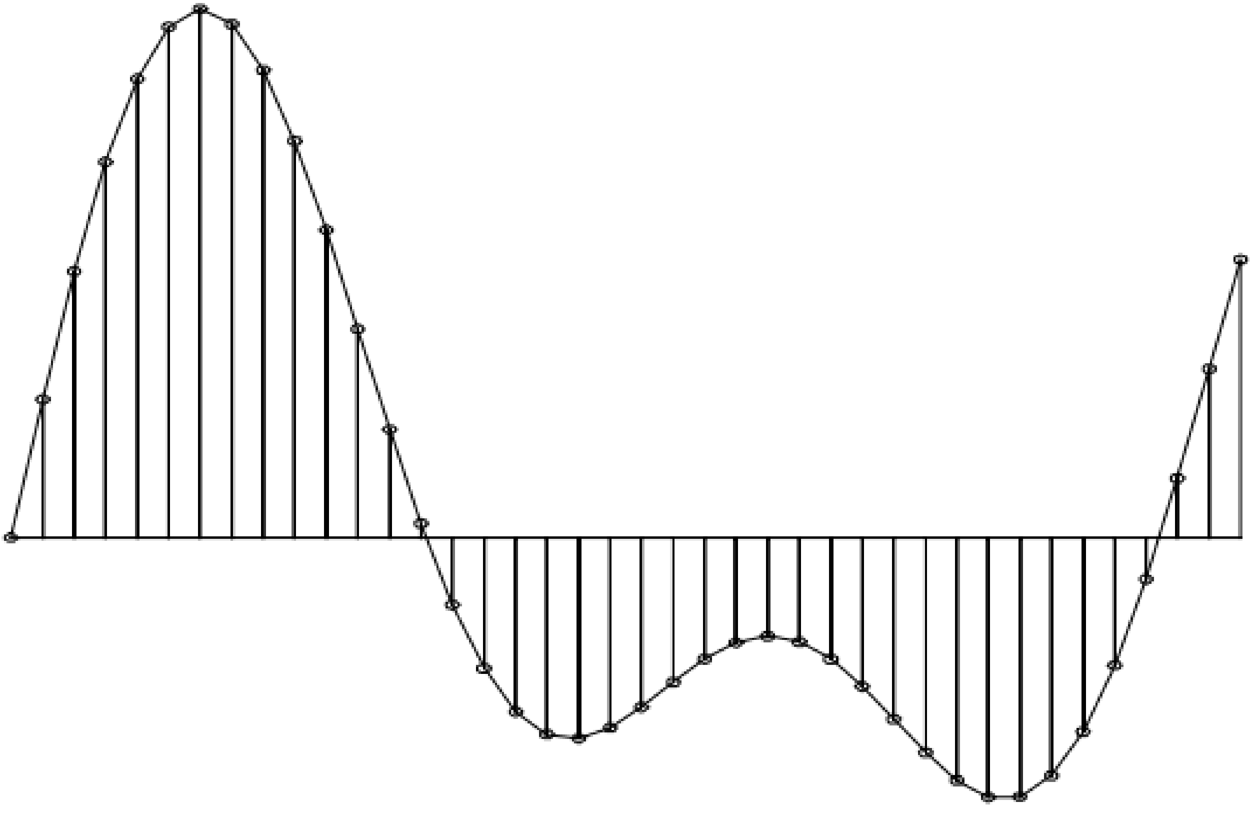
Sampling

- In selected channels
- With the scaling that has been set
- With the sampling parameters given
- We can continuously see the measured signals on the screen
- We can copy the data to the clipboard and then paste them into Excel, for example
- We can also save the measurement data to a file

What can we use it for?

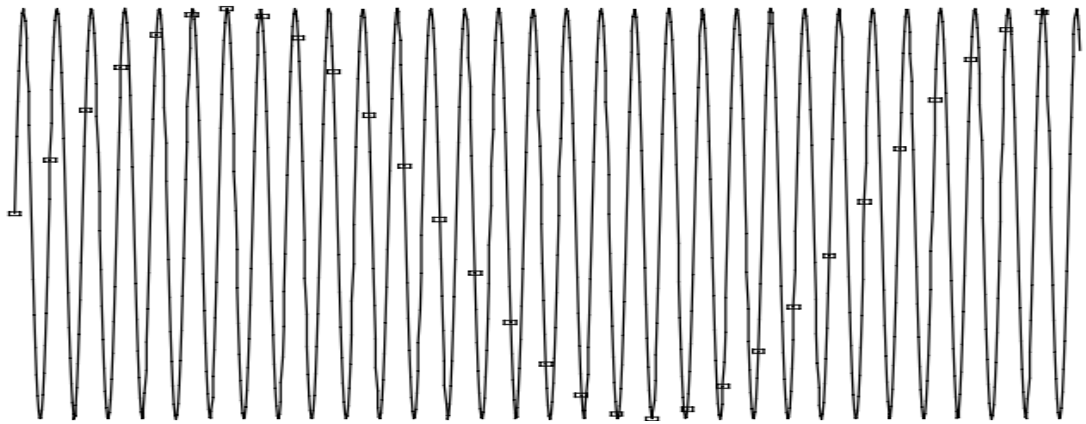
- Observing mechanical motion
- Demonstrating temperature changes
- Displaying photogate switching signals
- Measuring data series for subsequent analysis (eg, in Excel)

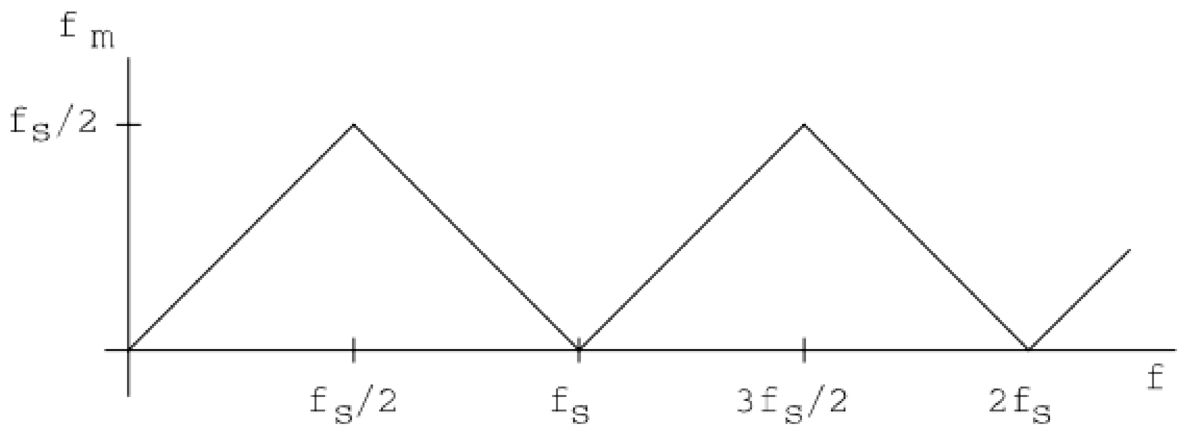
Sampling measurement (like a motion picture)



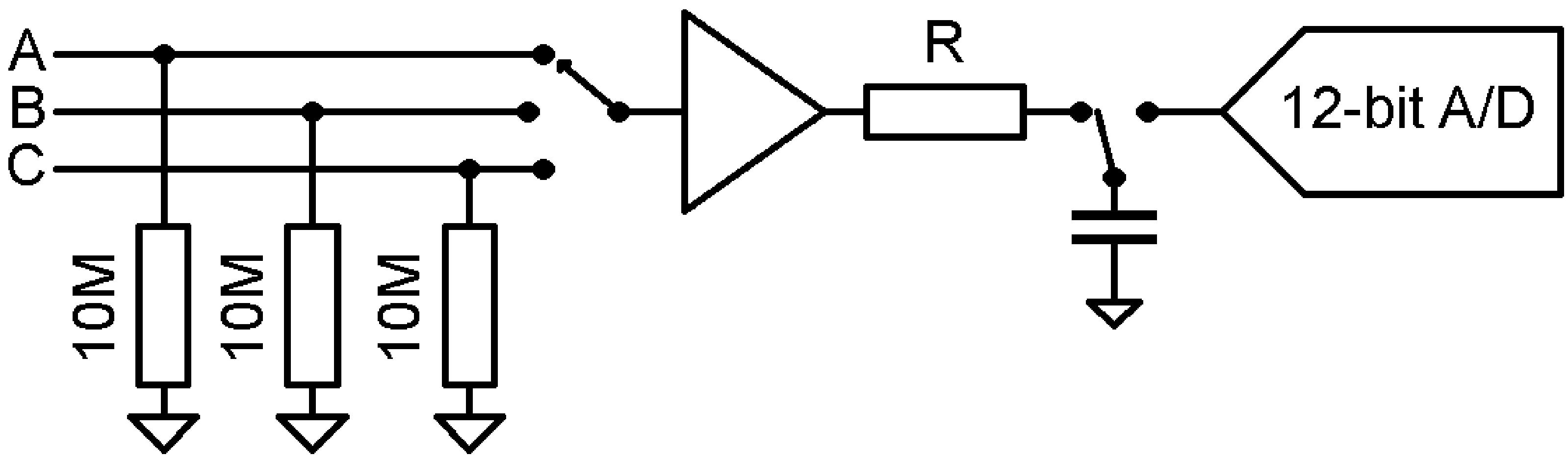
Sampling theorem:

sampling frequency > 2·signal frequency
(otherwise we should see the wheel rotating backwards in the film ☺)

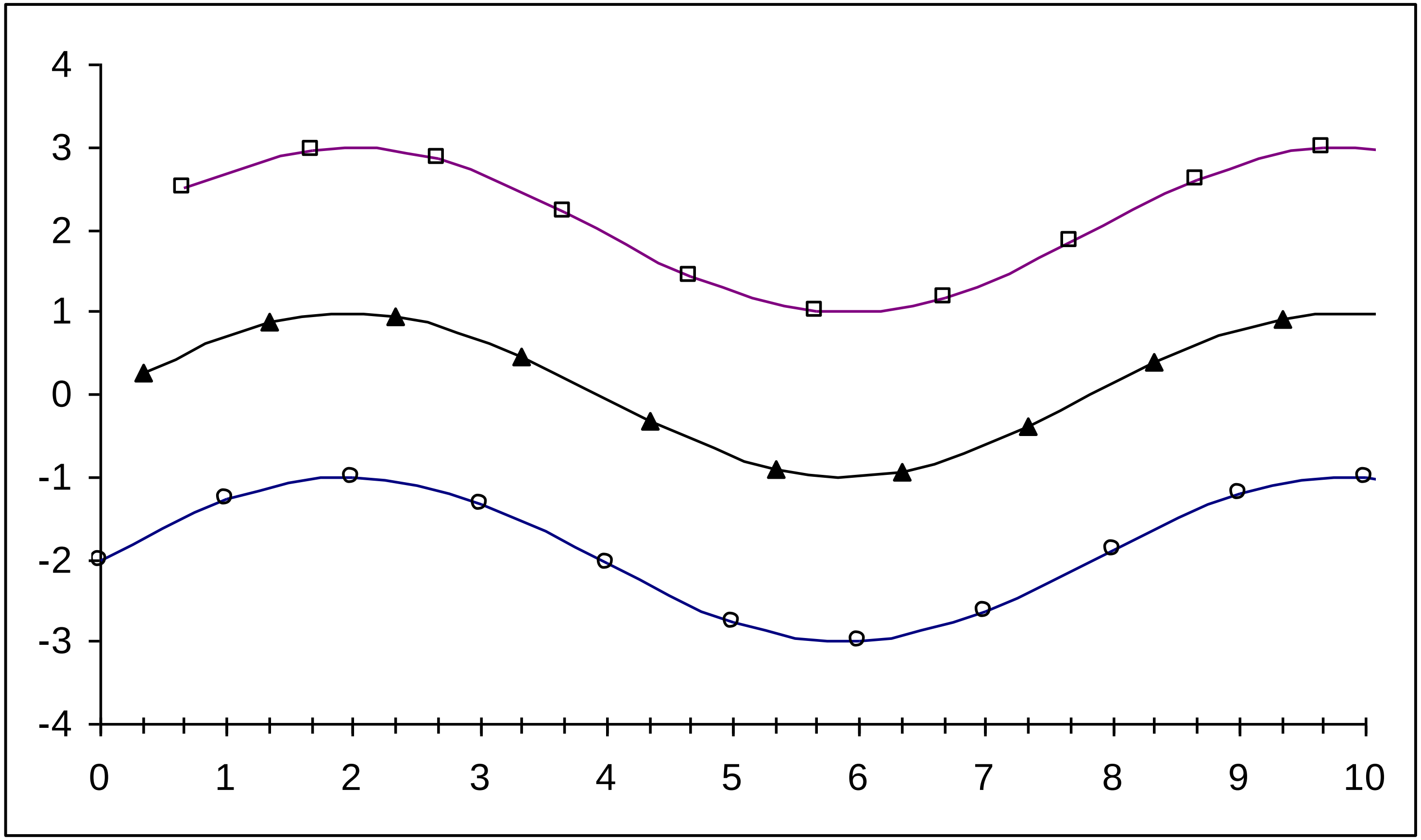




Sampling:
switching between three signals



Sampling:
switching causes a time shift between signals



Does it pose a problem?

- d*t* sampling interval (1/frequency)
- time shift: d*t*/3
- example:
  - 100 Hz , which means d*t* =10 ms
  - time shift: 3.33 ms
  - relative to 1 s on the display, it means 0.333%
- It is only noticeable if we have very few measurement points
- We know its value precisely, so it can be corrected for

Sampling rate

- Sampling at even intervals
- The number of data points measured in a second
- 1000/s maximum, which means a sampling interval of 1 ms
- The performance of the PC may limit the sampling rate

Time frame

- The measurement is continous, but the number of data points stored and displayed is limited
- T time frame: the length of the time interval displayed
- The number of data points displayed: $T/\mathrm{d}t = T \cdot rate$
- For performance reasons, there is an upper limit to this number (currently 10000)

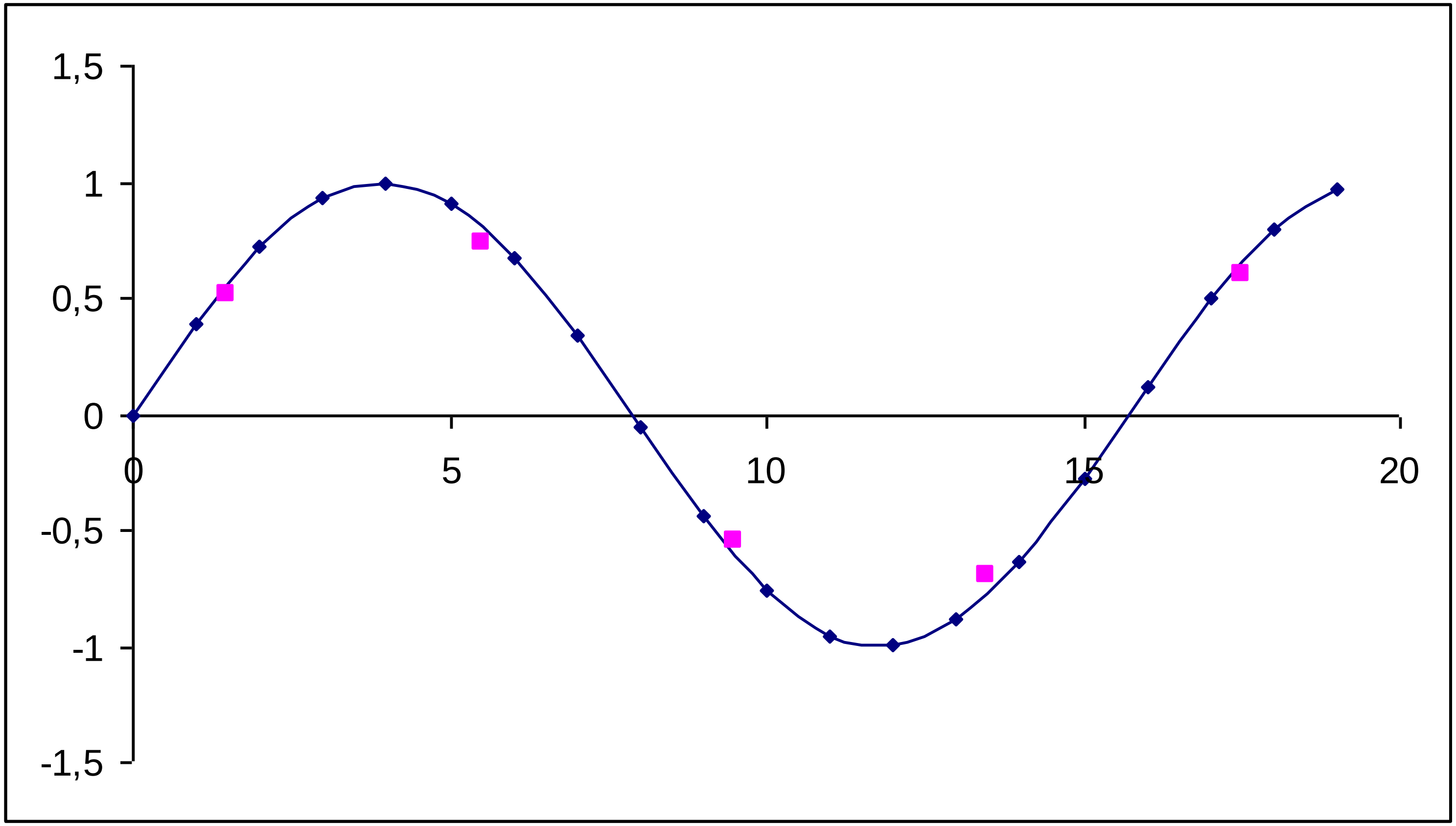
Refresh rate

- Refreshing the data on the display is periodic
- It strongly depends on the performance of the PC how high the refresh rate can be
- Start with a lower value
- When increasing the refresh rate, keep an eye on the responsiveness of the software
- Sometimes we can make data appear more plastic by reducing the sampling rate

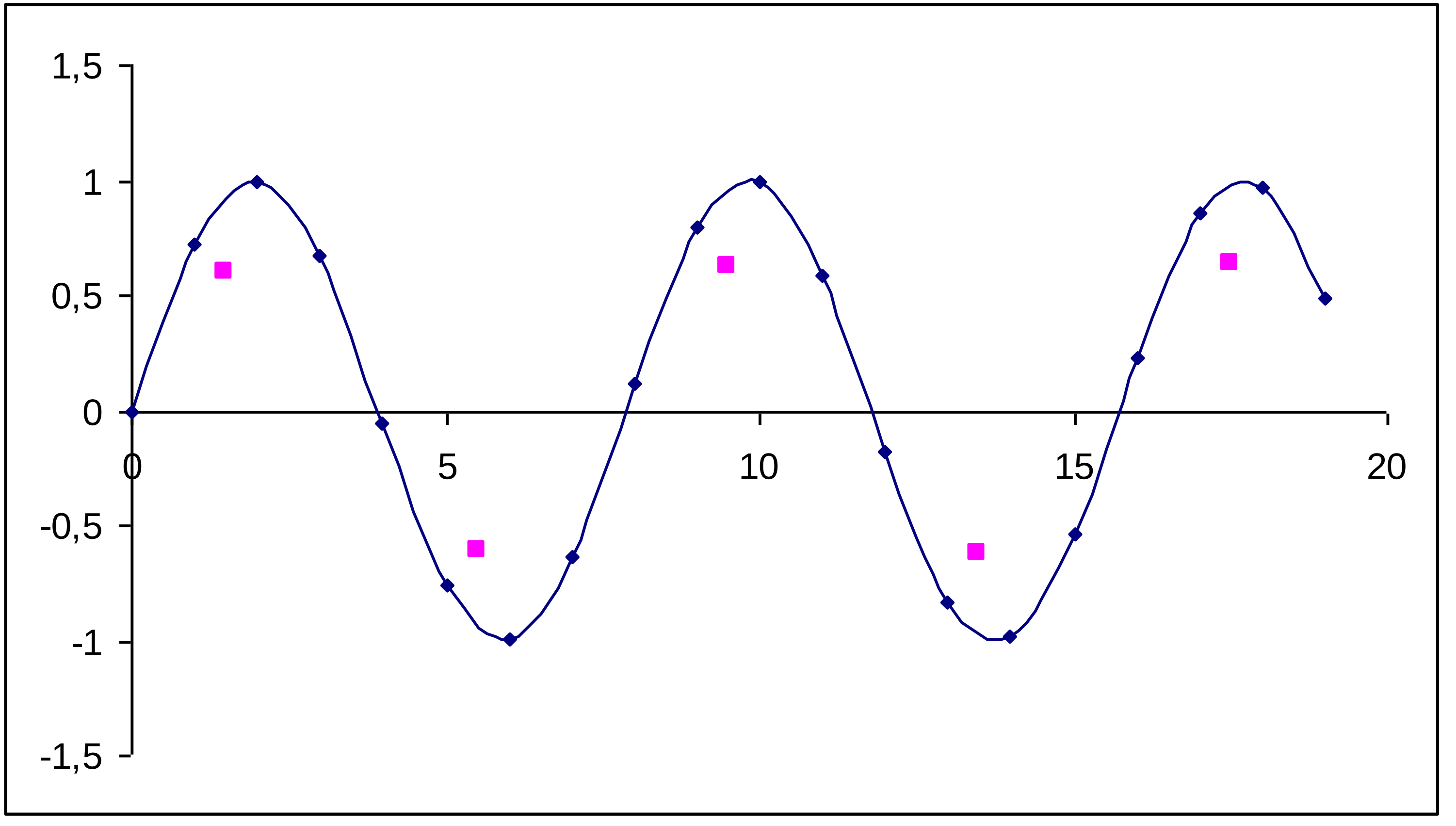
ADC averaging

- The hardware measures several data points and adds them up
- 1, 4, 8 or 16 data points can be averaged
- This does not change the sampling rate (when averaging, the device increases its internal sampling rate)
- Improves the resolution
- Random noise helps!
- It does not reduce deterministic errors!

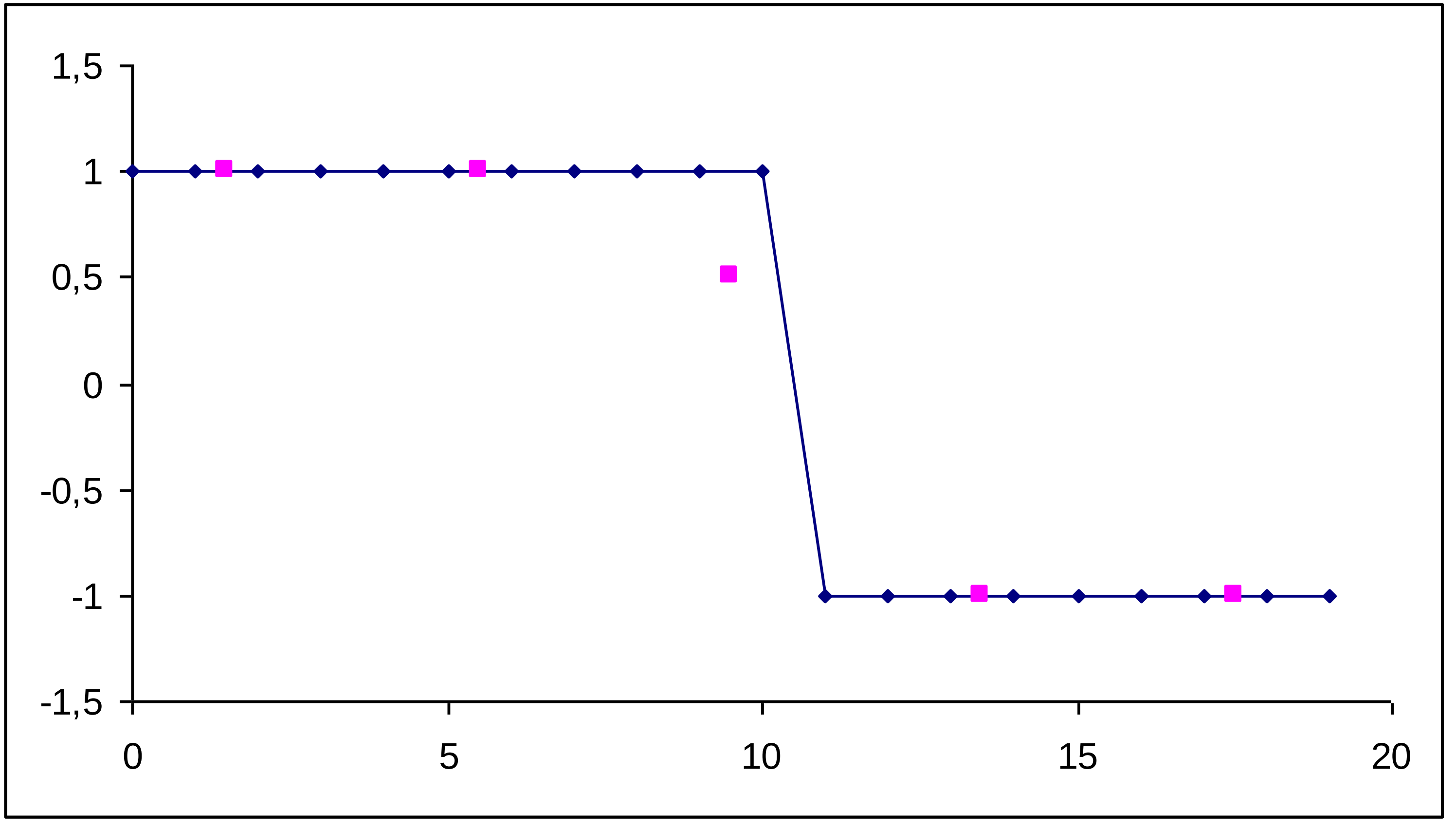
Effect of averaging



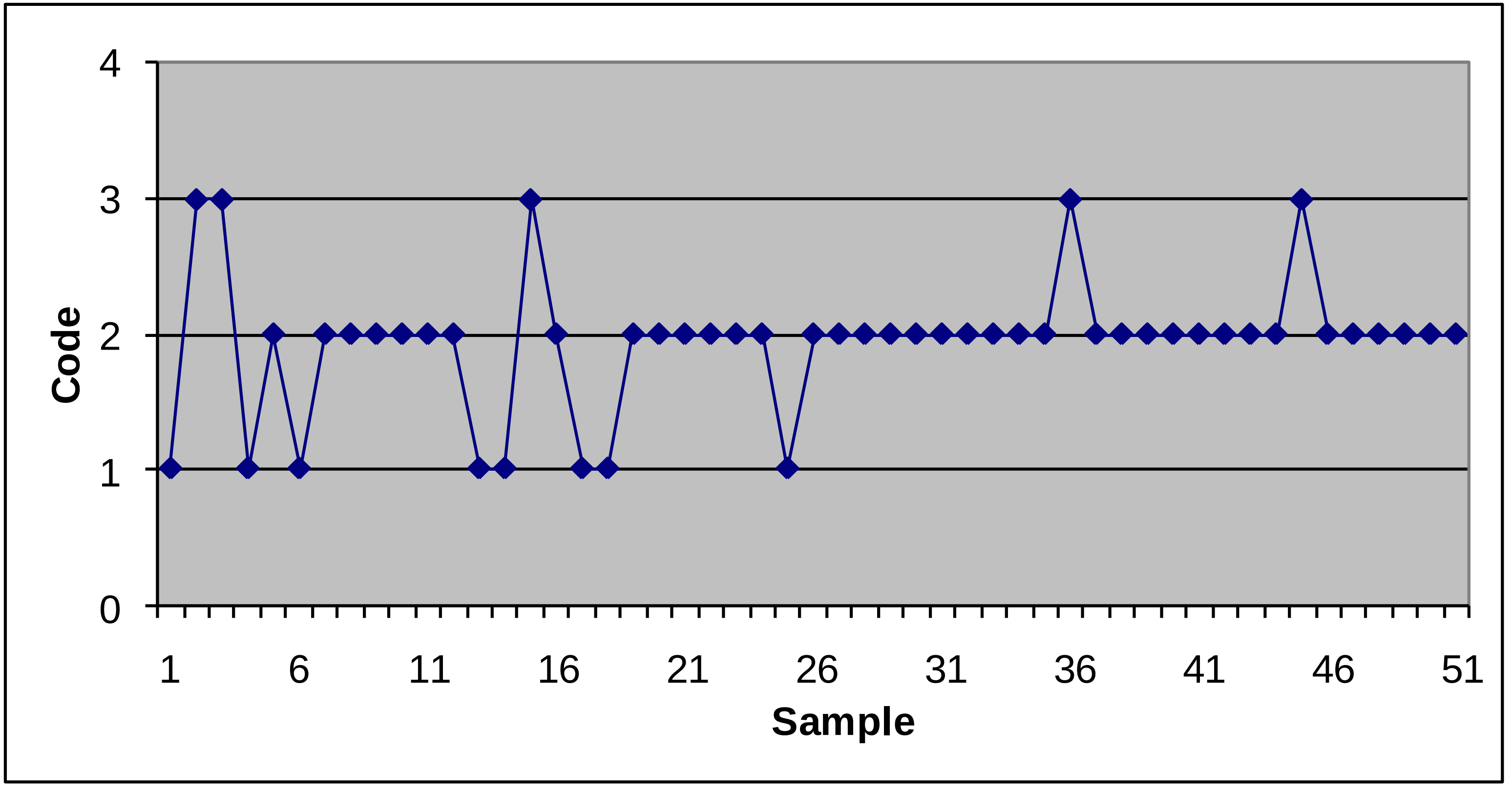
Effect of averaging on fast signals



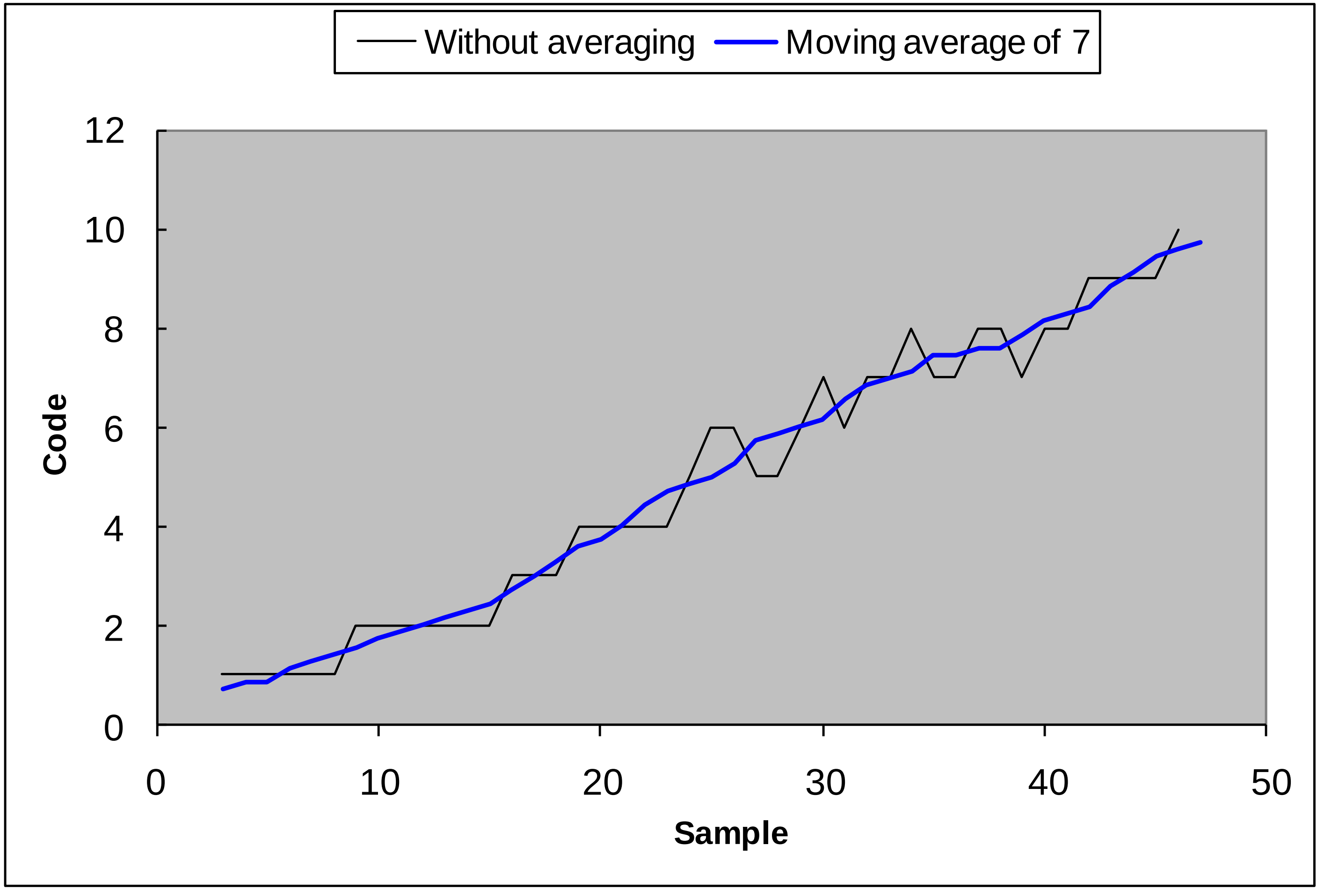
Effect of averaging



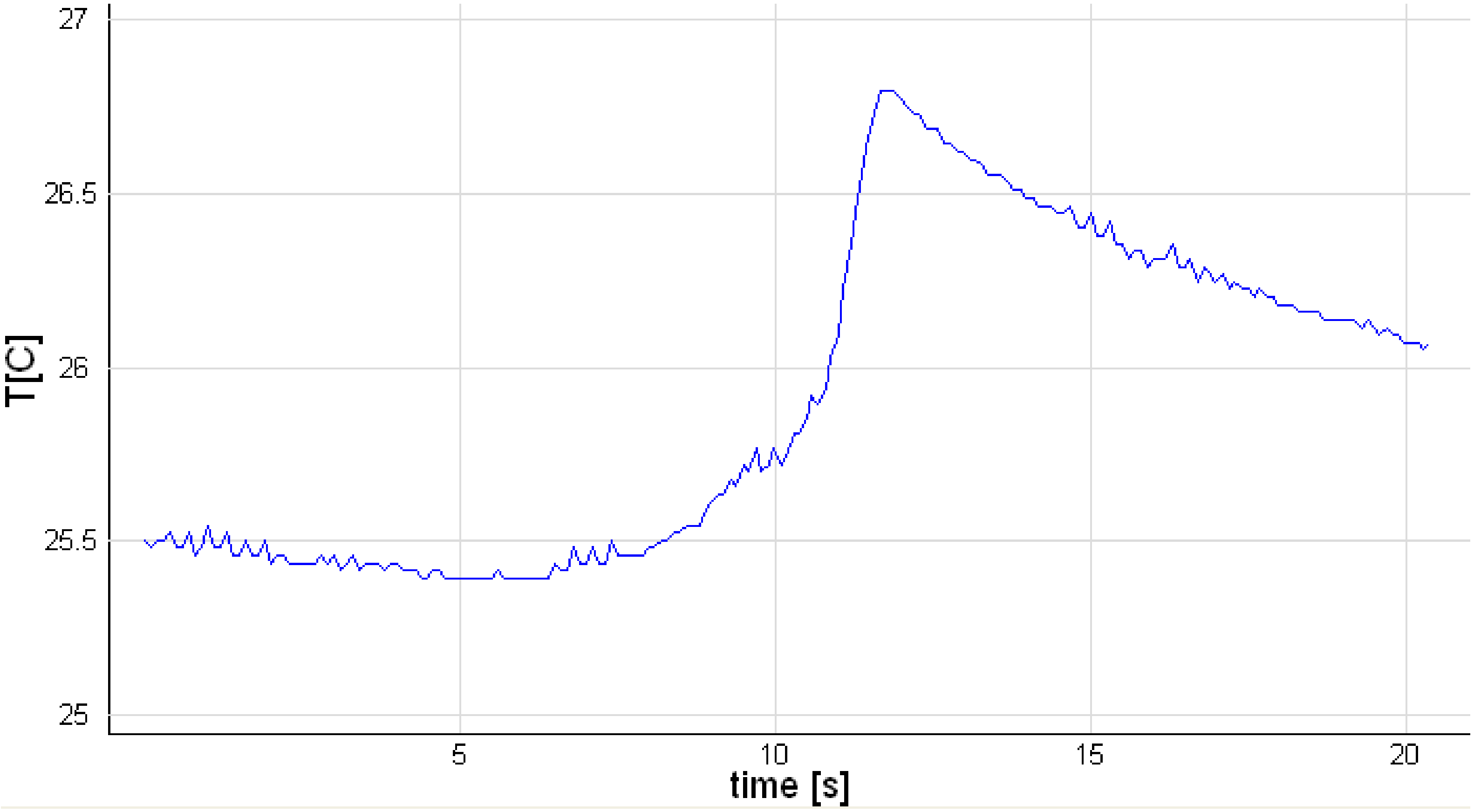
A/D converter noise



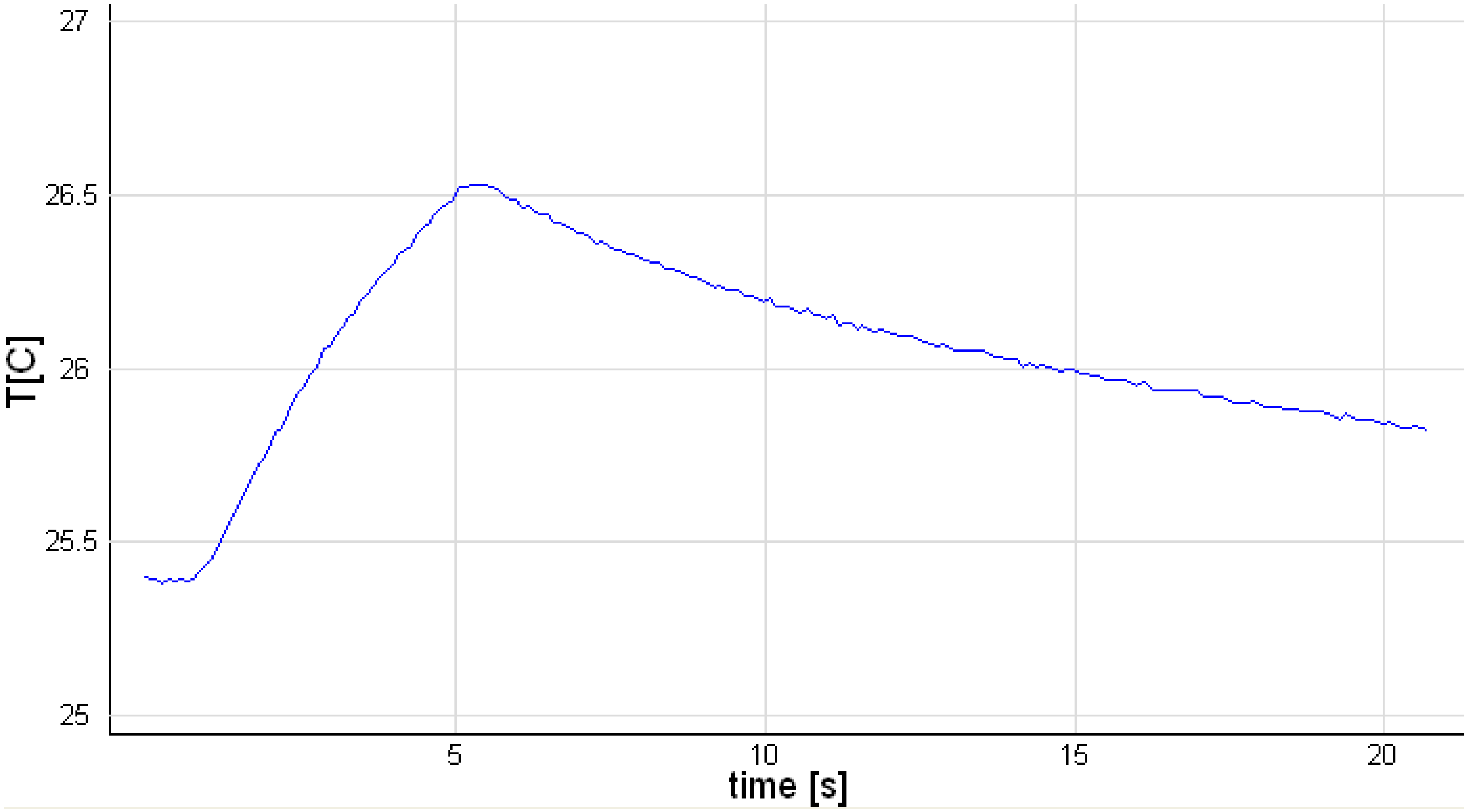
Noise can improve resolution an example: measuring a linearly changing signal



Measuring temperature without averaging



Measuring temperature using averages of 4 data points

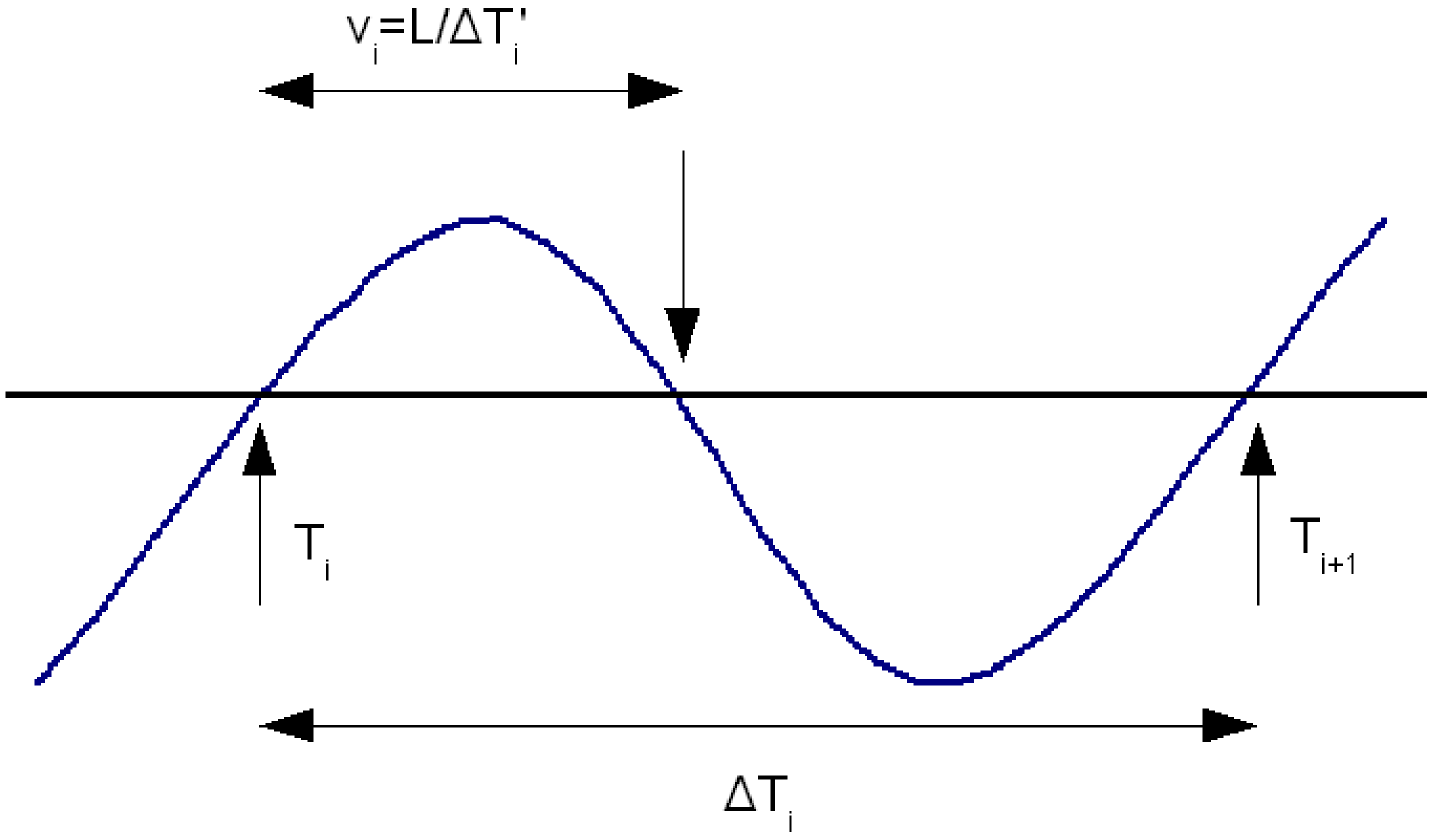


Level-crossing measurements

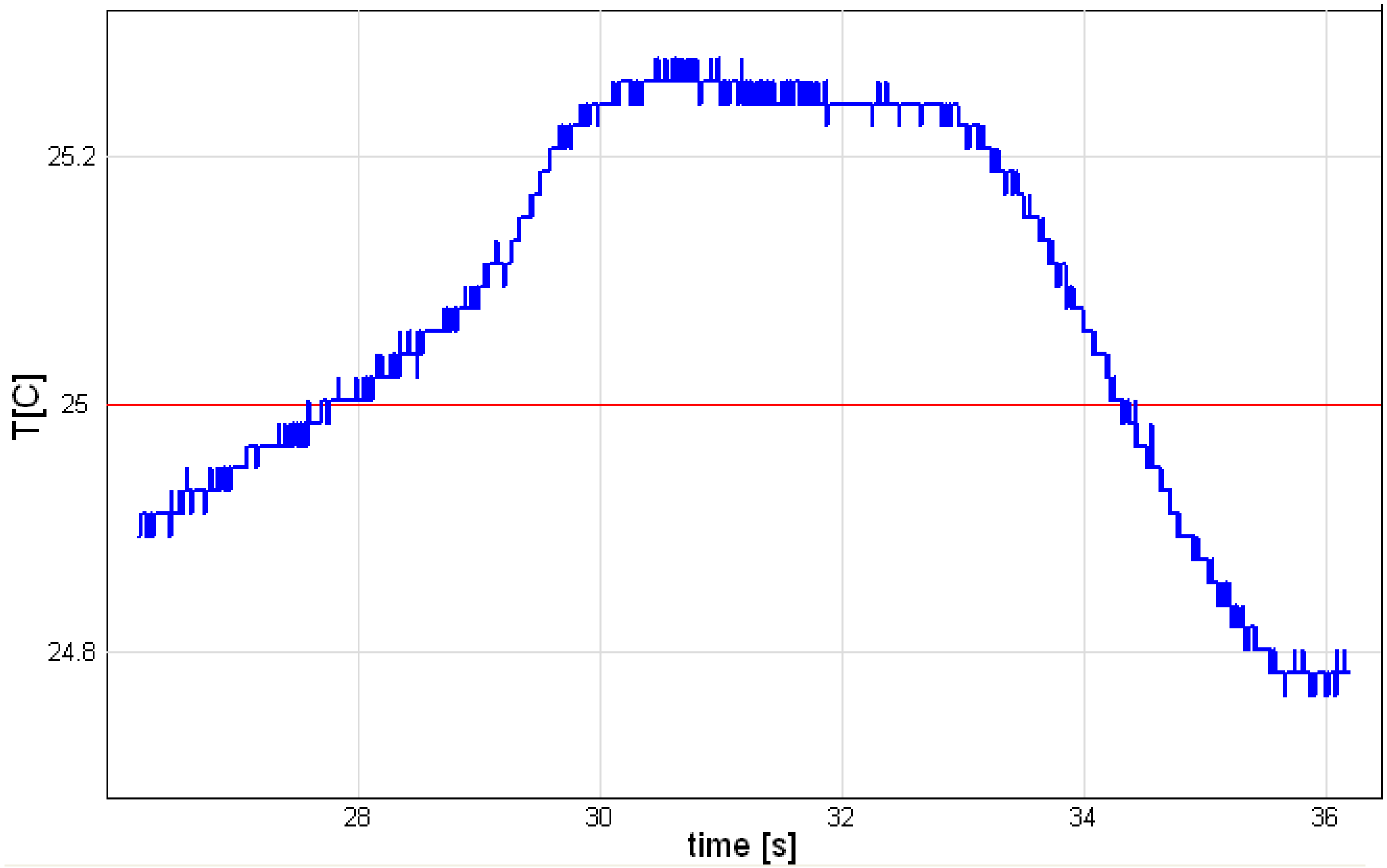
Detecting time instances of events

- Events can often be linked to the level crossings of a signal, for example:
  - The signal of a photogate switches when the detector is covered.
  - The value of the acceleration in periodic motion
  - The value of the temperature during cooling
- Time intervals and even speed can be measured

Level crossings of a signal



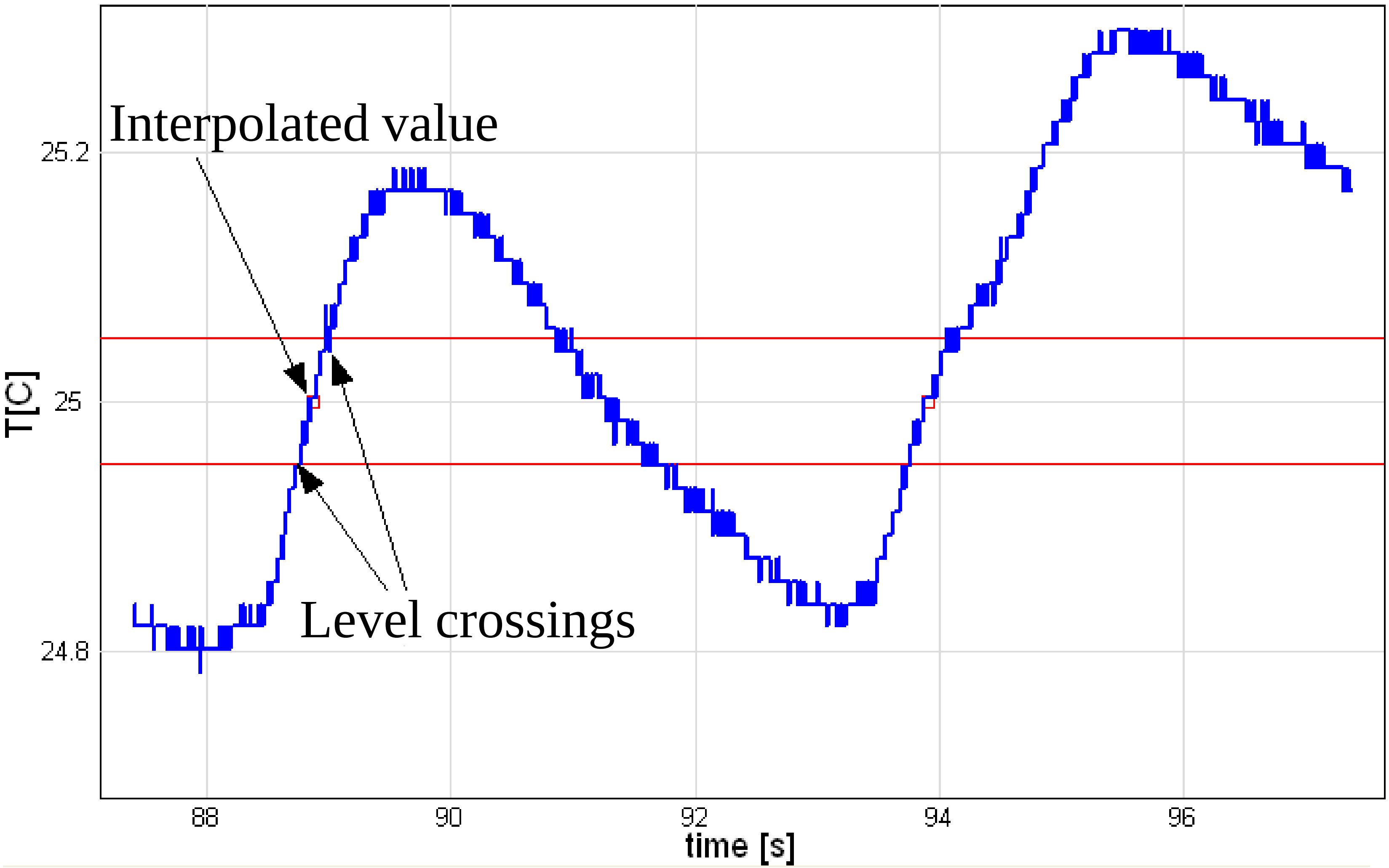
So far, it has been theory. What about a slow, noisy signal?



Slow or noisy signals

- Detection accuracy degrades
- Noise may cause random level crossings
- Typical solution: two threshold levels with hysteresis (like thermostatisation):
  - Upwards crossings: against the upper level
  - Downwards crossings: against the lower level
- Interpolating the crossing point can even improve the time resolution

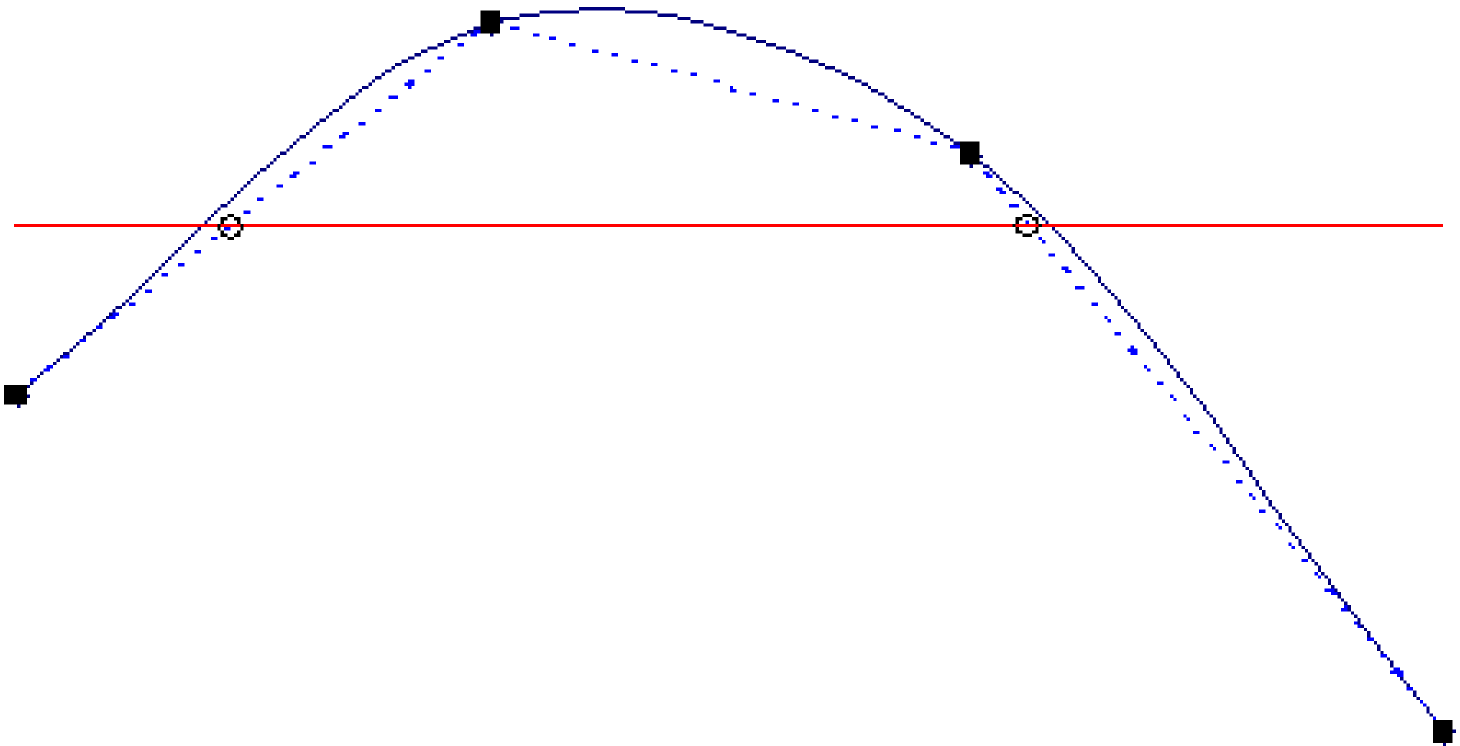
Two threshold levels



Effect of the time resolution

- The precision of the time base is 0.5%
- Time resolution is dt
- Relative error: dt/t
- If there are more level crossings, the error is not cumulative (it remains dt)

Interpolation improves resolution



Measuring time instances, intervals and speeds

- The program calculates and stores the level-crossing instances
- Upwards crossings:
  - for measuring time instances and periods
- Downwards crossings
  - used in speed measurements
- Data can be copied to the clipboard

Settings

- Sampling rate
- Level
- Hysteresis
- Object length for speed measurements
  - Time resolution is 1/rate
  - We can calculate the resolution of the speed from this value
  - Do not choose an object that is too short
  - What we measure is an average speed for the interval in which the sensor is covered

Example: using a photogate to measure the swing time of a pendulum

- Sampling rate: 100 Hz → 0.01 s time resolution
- We measure a swing time of approximately 1 s
- The aim is to determine the speed of an object which covers 5 cm in the path of the light
- The resolution:
  - Swing time: 1% for value of 1 s
  - Speed: 10% for a value of 0.5 m/s